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EFFECT OF TEMPERATURE OF REGENERANT ON REMOVAL OF RADIONUCLIDES FROM ION EXCHANGE RESINS

Several papers have reported on the use of cationic ion exchange resins for removing radiostrontium from milk in fixed-bed columns (2, 3, 7); others have shown that I^{131} can be similarly removed with anionic resins (1, 4, 6). Economical means for regenerating the resins (stripping the radionuclides from the resin) are necessary for commercial feasibility of these removal processes. Radiostrontium may be stripped from the cationic resin with a mixed Ca, K, Na, and Mg chloride solution. This solution also equilibrates the resin with an appropriate charge so that the minerals are maintained at near the composition in the original milk. A suitable anion salt solution for charge equilibration (sodium salts of citrate, phosphate, and chloride) is not effective for removing I^{131} from the resin. A 2 N HCl solution can be used, although a comparatively large volume is needed.

The present study was made to determine the effect of temperature of regenerant (stripping) solutions on the removal of radionuclides (I^{131}, Sr^{85}, and Cs^{134}) from resin columns.

Effect of temperature on removal of I^{131} from an anion resin. Milk in vivo–labeled with I^{131} (approximately 1 μc/liter) was passed through five separate columns of anion resin (Dowex 2 ×-8) which were previously regenerated with a mixed sodium solution of citrate, phosphate, and chloride (6). At the completion of the milk cycle each resin column contained essentially the same I^{131} activity. After rinsing free of milk with distilled water, thirty bed volume (rbv) per minute was used for all columns, at temperatures of 76, 100, 120, 140, and 160 F. A flow rate of one-fourth resin bed volume (rbv) per minute was used for all columns. Fifteen-milliliter aliquots were taken from each bed volume fraction passing through the columns and assayed for $Iodine^{131}$ with a single channel gamma spectrometer.

Another experiment was made to determine the effect of flow rate of the regenerant (2 N HCl) through the columns on the removal of I^{131} from the resin at 76 and at 160 F. The milk was labeled with I^{131}, as stated above. However, all of the milk was passed through a single resin column. The resin was cleaned and rinsed thoroughly, then removed from the column and divided into four equal fractions, each of which was transferred to separate columns for the regeneration cycle. Regenerant flow rates of one-sixteenth and one-fourth rbv per minute were employed at each of the above-stated temperatures.

Table 1 shows the effect of heating the HCl solution on the removal of I^{131} from the resin. The amount removed increased significantly with increasing temperature.

TABLE 1

Influence of strip solution temperature upon removal of I^{131} from resin

Bed volumes of strip passed through column	Temperature 76 F	100 F	120 F	140 F	160 F
	(% Removal)				
10	19	15	26	39	55
20	35	39	67	93	97
30	50	57	84	100	100

Table 2 shows the differences in stripping effectiveness at flow rates of one-sixteenth and one-fourth resin bed volumes per minute for temperatures of 76 and 160 F, the higher temperature and slower flow rate being more effective. The higher removals recorded in Table 2 for one-fourth rbv than for those shown in Table 1 at comparable temperatures (76 and 160 F) are probably due to differences in the procedure used to prepare the resins for the regeneration cycle. Removal of the resin from the column (data presented in Table 2) no doubt resulted in a more uniform distribution of I^{131} activity from top to bottom of the column than for the first experiment, in which the distribution was essentially undisturbed after the milk cycle.

Data presented above show that heating of the regenerating solution will result in a marked reduction in the amount of HCl required for removing a given quantity of I^{131} from the resin. The saving in time is also of practical significance.

Effect of temperature on removal of Sr^{85} from a cationic resin. Milk in vivo–labeled with $Strontium^{85}$ was passed through a cation exchange column which had previously been charged (regenerated) with a mixed solution of $CaCl_2$, KCl, NaCl, and $MgCl_2$ (3). The resin column was then washed free of milk with

TABLE 2

Influence of strip solution flow rate and temperature on removal of I^{131} from resin

Bed volume of strip passed through column	Flow rate through columns (rbv per min)			
	.25	.0625	.25	.0625
	76 F		160 F	
	(% Removal)			
10	34	41	83	89
20	60	81	99	99
30	75	98	100	100

distilled water, thoroughly mixed and divided into four columns, each containing 100 ml of resin. Twenty bed volumes of mixed regenerating solution were passed through Columns 1, 2, 3, and 4 at temperatures of 80, 110, 140, and 170 F, respectively. The flow rate used was one-eighth rbv per minute. Each bed volume fraction passing through the columns was assayed for Strontium^{85} with a single channel gamma spectrometer.

Figure 1 shows the relationship of temperature to the number of resin bed volumes of regenerant needed to strip various amounts of strontium from the resin. To strip 97% of the strontium from the resin, 9.78, 8.65, 7.2, and 6.45 bed volumes of fresh regenerant were needed at temperatures of 80, 110, 140, and 170 F, respectively. Work at this laboratory has shown that stripping (regeneration) of about 95% of strontium from the resin is adequate to maintain a high level of removal from milk over a period of several cycles. Within this range of removal about 12% less regenerating solution was used at 110 than at 80, 26% less at 140, and 34% less at 170 than at 80 F. Harris et al. (5) reported the advantage of reusing the regenerant, which should be considered in calculating the over-all per cent saving. If this system were employed, the absolute saving may be somewhat changed. Individual operations may vary as to the system for reusing the salt solution which will be most beneficial. Factors to be considered depend on size of operation, space for tanks to store used regenerant, cost of salts, etc.

The same general procedure as described for the strontium stripping was used for Cs^{134}. Four columns were included, two at 80 F, with flow rates of one-eighth and one-fourth rbv per minute, and two at 140 F, also at flow rates of one-eighth and one-fourth rbv per minute.

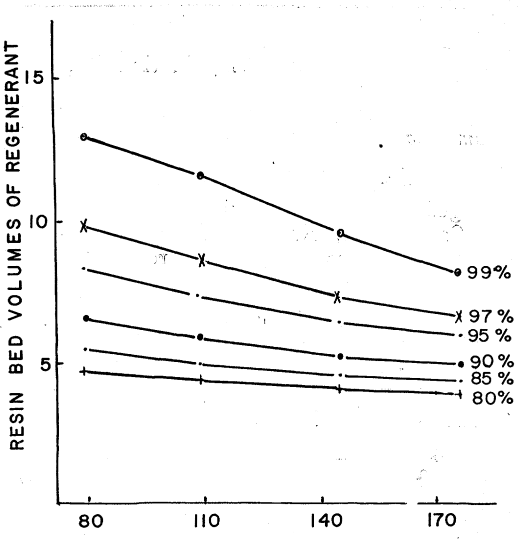

FIG. 1. Effect of temperature of regenerant on volume required for removing equal amounts of Sr^{85} from a strong acid (Amberlite IR-120) resin.

The regeneration was slightly more effective at the higher temperature, with approximately 20% savings of regenerating solution, although this difference was not as pronounced as in the case of strontium.

A slight increase in removal was observed at a flow rate of one-eighth over one-fourth at 80 F, however, at 140 F no advantage was noted at the slower flow rate.

Approximately 60% as much solution was needed to strip 95% of the Cs^{134} as was needed for the same amount of Sr^{85}.

When removing cesium from milk the removal drops to below 90% after 12 to 15 bed volumes of milk have been passed through the resin column. However, this could still be incorporated into a feasible operation, because of the relatively small amount of solution needed for stripping and regeneration.

SUMMARY

It is shown that the amount of Sr^{85} and Cs^{134} eluted from cationic ion exchange resin columns is increased by increasing the temperature of a regenerating salt solution; similarly, I^{131} elution from an anionic resin is increased by heating 2 N HCl used for elution. The advantage gained by heating the solutions may be partially offset by the added expense of heating. However, a definite advantage of such a daily operation may be the reduction of bacteria in the resin columns. If this method were used as a means to control bacteria, the two advantages thus gained should more than compensate for the added cost of heating the regenerating solutions. The reduction in operating time would also be an advantage.

D. G. EASTERLY
H. E. WALTER
L. F. EDMONDSON
Dairy Products Laboratory
Eastern Utilization Research and Development Division
Agricultural Research Service
USDA, Washington, D. C.

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